Of course, the direct application of these figures in any accurate calculation of the conditions of life among different races or at different periods of time is impossible, but they indicate in no uncertain manner the great differences acoustically in the environment of Asiatic races, of aboriginal races in central and southern Africa, of the Mediterranean countries, of northern Europe at different periods of time. We have explained for us by these figures why the musical scale has but slowly developed in the greater part of Asia and of Africa. Almost no traveler has reported a musical scale, even of the most primitive sort, among any of the previously unvisited tribes of Africa. This fact could not be ascribed to racial inaptitude. If melody was, as Helmholtz suggested, but rhythm in time and in pitch, the musical scale should have been developed in Africa if anywhere. These races were given to the most rhythmical dancing and the rhythmical beating of drums and tom-toms. Rhythm in time they certainly had. Moreover, failure to develop a musical scale could not be ascribed to racial inaptitude to feeling for pitch. Transported to America and brought in contact with the musical scale, the negro became immediately the most musical part of our population. The absence of a highly developed scale in Africa must then be ascribed to environment.

Turning to Europe, we find the musical scale most rapidly developing among the stone-dwelling people along the shores of the Mediterranean. The development of the scale and its increased use kept pace with the increased size of the dwellings and temples. It showed above all in their religious worship as their temples and churches reached cathedral size. The reverberation which accompanied the lofty and magnificent architecture increased until even the spoken service became intoned in the Gregorian chant. It is not going beyond the bounds of reason to say that in those churches in Europe which are housed in magnificent cathedrals the Catholic, the Lutheran and Protestant Episcopal, the form of worship is in part determined by their acoustical conditions.

This presents a tempting opportunity to enlarge on the fact that the alleged earliest evidence of a musical scale, a supposed flute, belonged to the cave-dwellers of Europe. This and the impulse to sing in an empty room, and the ease with which even the unmusical can keep the key in simple airs under such conditions, are significant facts, but gain nothing by amplification. The same may be said of the fact that since music has been written for more crowded auditoriums and with harmonic accompaniment the air has become of less harmonious sequence. These and many other instances of the effect of reverberation come to mind.

In conclusion, it may be not out of place to repeat the thesis that we would not merely with Helmholtz regard melody as rhythm in time and rhythm in pitch, but also as harmony in sustained tones, and see in the history of music, certainly in its early beginnings, but possibly also in its subsequent development, not only genius and invention, but also the effect of physical environment.

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THE RELATION OF INSTINCT TO INTELLIGENCE IN BIRDS

IN the following observations an attempt is made to analyze the behavior of the wild bird in order to ascertain first, how their instincts are modified by their ability to learn, and secondly the degree of intelligence which they ordinarily attain. It may be taken as an axiom that if the bird be intelligent, it must use its intelligence in meeting the emergencies of daily life

and the dangers which surround its home. I shall refer mainly to nesting birds. In all cases the conditions are natural and the behavior free.

In considering the young we must distinguish between the altricious and precocious species, and remember that between such extremes every shade of difference exists. The cedar waxwing which is born blind and naked may be taken as a type of the altricious group. The moment it bursts its shell, unfolds and dries off, a new class of stimuli assail it. Its sensitive skin, with its tactile organs and ears, begin to register new emotions. Its most striking initial reaction is to rise upon its pot-belly as upon a central pillar or foot, open its wide mouth, and thus display its light-rimmed scarlet "target" of a throat. This reaction might arise from hunger, but it certainly follows mechanically in response to any sound or vibration to the nest. At birth such a nestling is a nearly perfect reaction machine; its responses are automatic and reflex, and within the limits of fatigue they are as uniform and continuous as the responses of an electric bell. At this sign from the young the parent goes in quest of prey, discovers and seizes it, hammers it to a pulp, it may be, and returns with it to the nest. The nestling repeats the sign, and the food is pressed gently down into its sensitive throat; the swallowing reflex is started, and the little bird gets its first meal. Remove this bird from its nest, and this feeding response is given as regularly and as continuously as before. Now approach the same nest upon the second, or better, upon the third or fourth day and apply the same tests. It will be found that the feeding reaction no longer comes uniformly and invariably, and if the young is again removed from its nest, the response is still more difficult to obtain. The characteristic feeding reaction is now regular and predictable only in the presence of the parent, and in its proper environment—the nest. Therefore in forty-eight hours the young cedarbird begins to show the first sign of intelligence by learning to limit its reactions to those which count, or in other words by learning to recognize the coming of the parent. Yet this association, which seems to mark the dawn of avian intelligence, is often far from precise, for when at the age of eight or ten days of age a nestling rises to stretch on the nest its companions will crowd about it and "beg" in the same excited manner, as if it were really the parent just alighted on the nest with food in bill.

All birds form associations with their nest or the spot on which they are born, and to most it signifies warmth, a place to be fed, and comfort in general. In some cases the young learn to return to the nest, and may go in and out of it for days or weeks. Altricious birds when once out of the nest seldom return, but this is not due to any lack of association, but to their rising instinct of fear favoring that of flight, or at least the desertion of the nest and possibly their concealment by hiding, when the attunement of these instincts is imperfect. In a few cases the same nest or nest-site may be occupied by the same birds for many successive years. There is no evidence that the young of any birds distinguish their nest as a *nest* at all, or as anything more than a place, as a part of a tree or of the earth.

The young kingfisher spends four weeks in its underground tunnel, and towards the close of this period, as I have explained elsewhere, it acquires the curious habit of walking backward. In the education of the young bird it is not necessary to assume that any conscious or deliberate part is ever played by the adults. The phenomena are satisfactorily accounted for by instinct, including imitation on an instinctive basis, and association, involving

experience and the power to learn. In altricious birds imitation is not very effective before the young leave the nest, but is more marked in precocious birds at an early period. Imitation is most striking in fully grown but immature young, as in bluebirds, which still follow their parents, but are not wholly dependent upon them, or in gull chicks, which are fed by regurgitation, and often have to wait a long time before the food is produced.

Does the adult bird show intelligence in serving the proper quantity of food, and in distributing it to the young? The answer is no! What the old bird really does in effect is to "test" the reaction of the throat of each nestling, and await the response. If a bird does not respond quickly the food is withdrawn and another is tested. Thus is the food always passed around until a bird with the proper reaction time is found. There is no evidence that such "tests" are deliberately or consciously made. The amount of food taken by the young is determined reflexly by the gullet, which acts as a brake upon the tendency of the young to gorge itself to suffocation. The bird with full gullet can not as a rule respond, and must wait.

Does the old bird display intelligence in the kind of food served, or in the treatment which it receives? It probably does. While a good deal of instinct is involved in all these matters, the parent does not act like a machine, but the young are provided with food adapted to their growing needs. A gull chick, one half hour old, gets small pieces of predigested fish, while at three weeks of age it may be invited to bolt an entire squid.

What can be said of the general intelligence displayed by old birds? We find that their various instincts become modified or refined by habit or association at almost every step. Thus behavior becomes ever more definite, and their life tends to run in grooves. They quickly form the habit of going to their nesting site by a definite path. If the branch which holds the nest is cut off and removed but a few feet away, the old bird will try to follow her usual course and hover at the point in space formerly occupied by the nest, even when in sight of her young, and will repeat these actions many times before actually going to the nest. But this behavior abruptly ends when the new site of the nest is once visited. After the nest is built, or even while construction is in progress, a definite habit of approach is formed, which may involve walking along a certain limb or grasping certain twigs. The habit of entering the nest from a certain side, facing the same way while sitting on the eggs, grasping the same branch when inspecting or cleaning the nest, and leaving the nest in a definite manner, are all more or less stereotyped and fixed by habit in a relatively brief course of time.

Do birds discriminate their own eggs and proper young? Very many do not, but some do, sooner or later. The success of the European cuckoo, or the American cowbird, whose young are reared by foster parents of many species, would argue for little power in this direction. Yet, in some cases, the foreign body is removed, or the nest is deserted through fear.

In the cyclical instincts of the reproductive period intelligence in the wild bird is mainly displayed by the formation of habits through association. In the same way drinking and bathing places, perches, spots for dusting, for sun-bathing and sleeping are resorted to by habit, for longer or shorter periods, according to the other conditions which modify behavior.

How does the wild bird meet emergencies? Do their acts ever suggest abstract thought, deliberation and planning, and do they generally offer any effective aid to companions in distress? Such important

subjects can not be summarily dismissed. Many observations would certainly warrant a negative answer to the last two questions, while some would not. Not only do we need more pertinent and reliable observations, but a more exact analysis, as well as more certain criteria.

A chipping sparrow will pluck a horse hair from the mouth of a nestling, while another bird like an oriole will stand by and see its mate hung until dead without attempting to release it. A robin will tug at a string which has caught on a limb, but is never seen to fully meet the situation by releasing the string. It will make several turns of a cord about a limb and leave the other end to hang free without any relation to the nest, so that its effort is useless. It ties no knots. The gull, according to abundant and competent testimony, will carry shellfish to a considerable height, drop them on the rocks or hard ground, and repeat the experiment until it gets the soft meat. This suggests adaptive intelligence or even analogical reasoning, but probably does not rise above the level of associative memory. The habit is probably casually formed, and is certainly rare.

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SCIENTIFIC BOOKS

Early Devonic History of Northeastern North America. Memoir 9, New York State Museum, New York State Education Department, 366 pp., 48 plates, sections, diagrams, maps, etc. Albany, 1908. By J. M. Clarke, State Geologist, and Director of the New York State Museum.

In this magnificent memoir, with its princely plates and exquisite illustrations, the state of New York has once more shown the world how far science and art had reached towards a realization of satisfactory results in describing and illustrating the hard facts of geology in an orderly and delightful manner.

To the student of paleontology and stratigraphical geology this handsome contribution to the history of early Devonian times will be most welcome. It fills a long-felt want, and serves to tie together a number of faunas and formations with others in the State of New York as well as beyond. Science, and geology especially, knows no political boundaries. As Dr. Clarke very aptly puts it, "The New York series of formations spreads away from its typical region to all points of the compass, and in all these directions, however far it extends, light is to be sought for the explication of past geologic conditions in New York." "The state, . . . does not and never can in itself afford the solution of its own problems." Professor James Hall for the sixty-three years that he was in office at Albany had shown that the New York series extended beyond the limits of New York State. The standards laid down by the fathers of geology in northeastern America, like Hall, Logan, Dana, Billings, Emmons and many others, were to be kept high and to the fore.

The subject-matter dealt with by the distinguished successor to James Hall in the memoir before me was obtained by Dr. Clarke in the Peninsula of Gaspé, in southeastern Quebec. After describing the general distribution of the "Early Devonic of New York" and pointing out their extension north and east, he then sets to the task of giving the geology of the region covered by the memoir. The geology of the Forillon, of Percé (a brief sketch of which had appeared in 1903 in advance sheets from the report of the paleontologist, 1904, and in Bulletin 107, Geological Papers, Albany, 1907) the Gaspé sandstones, etc., is followed by descriptions of the various faunas.

Three distinct faunas are noticed, and their rich harvest of forms new to science, or recorded afresh, constitute the bulk of the material on which the memoir is based. They are as follows:

I. Fauna of the St. Alban beds. Forty-eight species.

II. Fauna of the Cape Bon Ami beds. Of this fauna eleven species are recorded.

III. Fauna of the Grande Grève limestones. One hundred and sixty species.